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On the energetics of symmetric circulations

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A theory of available potential energy (APE) for symmetric circulations is presented.

The theory relies on the Hamiltonian structure of the conservative dynamics, is exact at finite amplitude, and has a local form. Both thermal and (angular) momentum constraints on the circulation are taken into account. Effects of forcing and dissipation can be included in the energy budget.

Momentum constraints prove to be important, for example, in diagnosing mechanically driven, thermally damped circulations. Applications, for the case of f-plane Boussinesq equations, and for the hydrostatic primitive equations are presented.

It is shown that in the new framework the APE of a symmetrically stable flow is zero, and that the diagnostic applied to a mechanically driven symmetric circulation properly reflects its causality.